Nutrient Criteria

Federal Water Pollution Control Act Amendments of 1971

Report of the Committee on Public Works, U.S. Senate, S. 2770, October 28, 1971

(S. 2770 → Public Law 92-500 → U.S. Code Title 33, Chapter 26)

Title I, Section 101 – Declaration of Policy

"This section establishes a policy that the discharge of pollutants should be eliminated by 1985"

Title III, Section 301 – Effluent Limitations

"This section clearly establishes that the discharge of pollutants is unlawful. Unlike its predecessor program which permitted the discharge of certain amounts of pollutants under the conditions described above, this legislation would clearly establish that no one has the right to pollute – that pollution continues because of technological limits, not because of any inherent right to use the nation's waterways for the purpose of disposing of wastes."

Module Outline

I. Nutrient Pollution

II. Statutory and Regulatory Basis for Nutrient Criteria

III. EPA's National Nutrient Criteria Program

IV. Scientific Basis for Numeric Nutrient Criteria

V. Technical Approaches

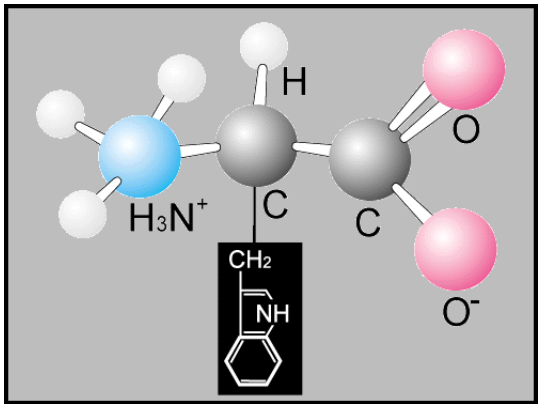
VI. Current Events

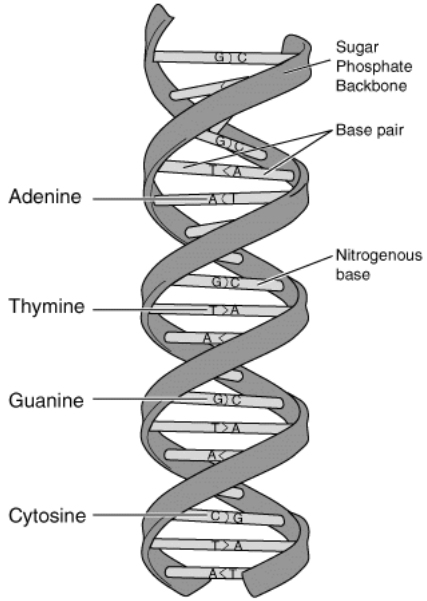
Take Homes

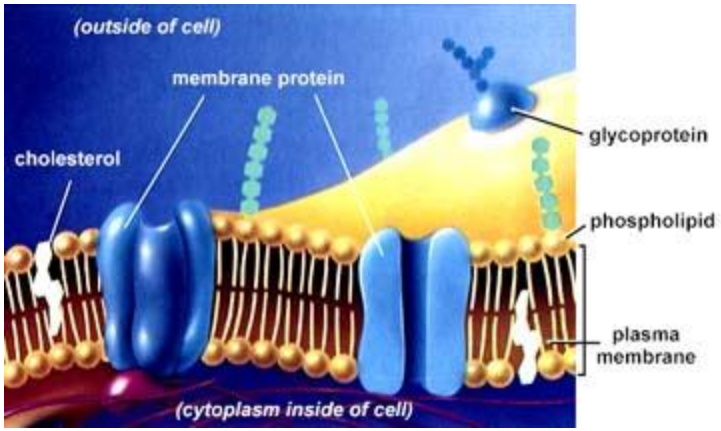
1. What is the nutrient problem?
2. What is legal basis for nutrient criteria?
3. Why are numeric criteria for nutrients preferred?
4. What is the science behind why numeric nutrient criteria are important?
5. How are numeric nutrient criteria developed?
6. What are States and EPA currently doing?

I. Nutrient Pollution: Aren't Nutrients a Good Thing?

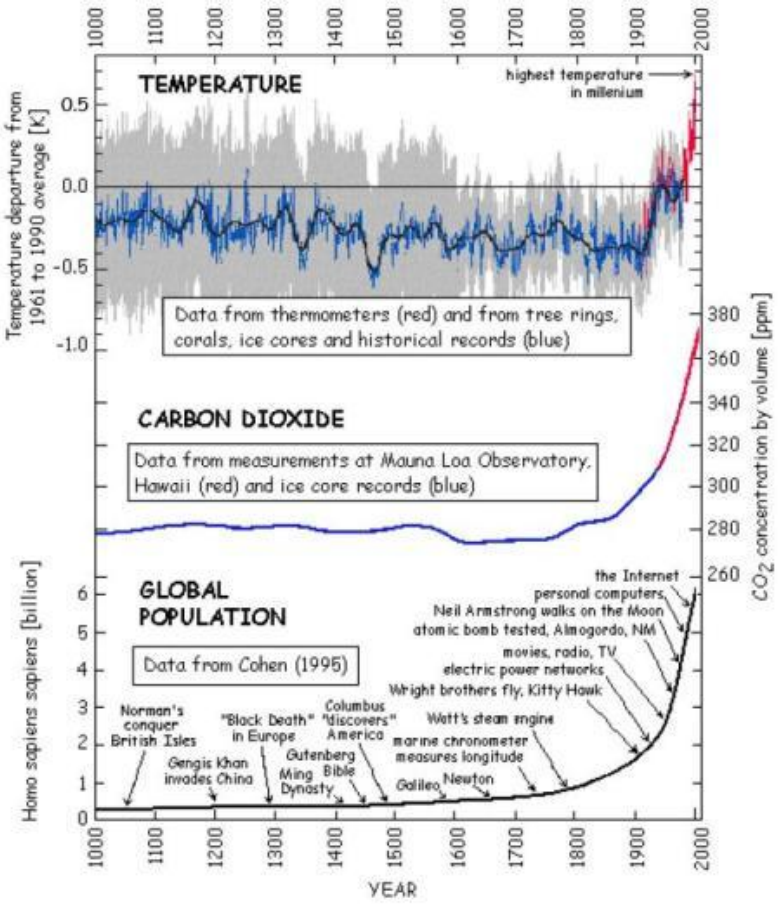
- Nutrients = nitrogen and phosphorus
- Total Nitrogen = dissolved (inorganic + organic), particulate
- Total Phosphorus = dissolved (inorganic + organic), particulate
- Organism: Growth, development, reproduction



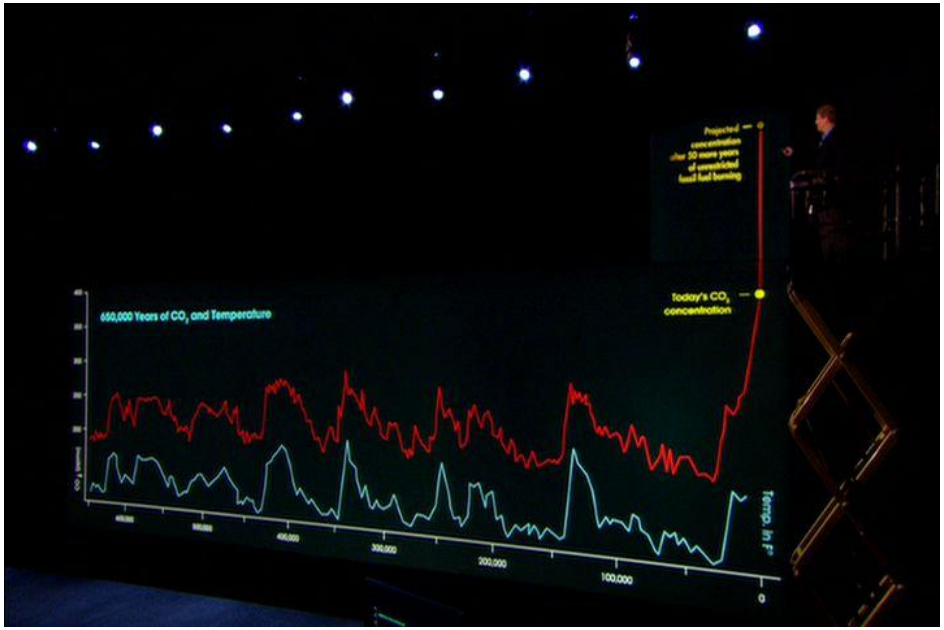




The Carbon "Hockey Stick"



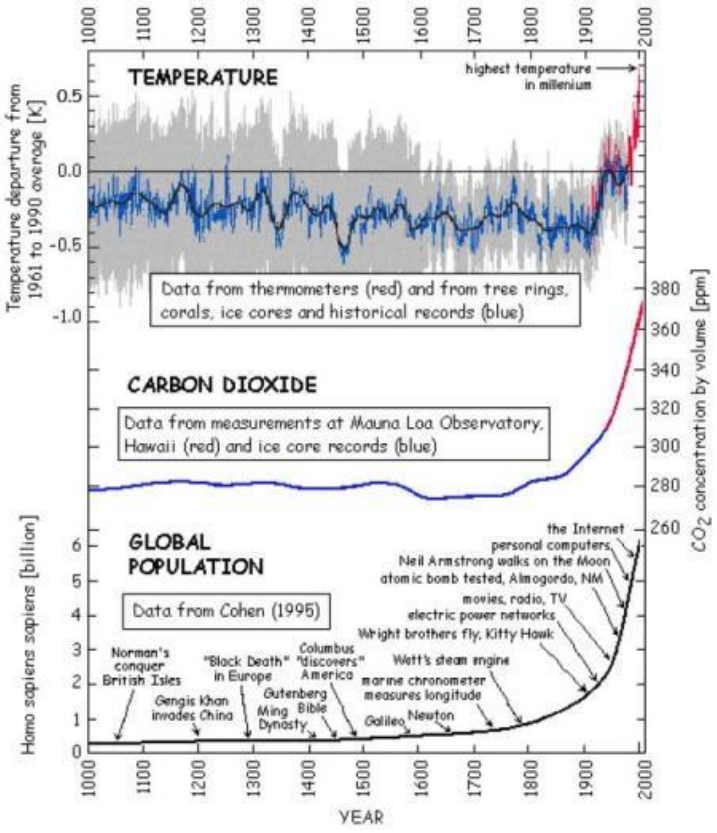
Exponential increase in global atmospheric CO_2 concentrations

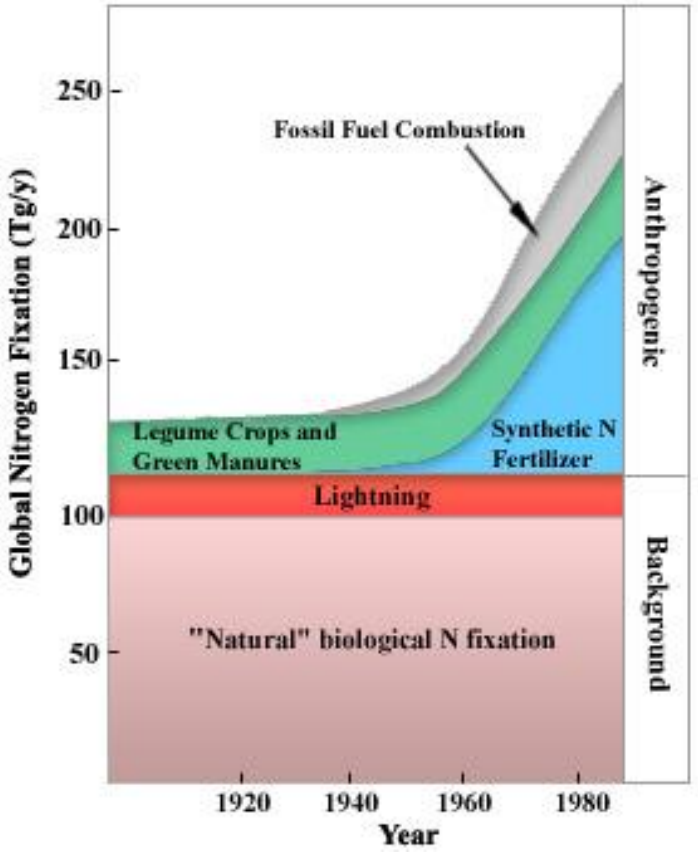


EPA Water Quality Standards Academy, December 13, 2011
http://www.epa.gov/waterscience/criteria/nutrient

“The Nitrogen Bomb”

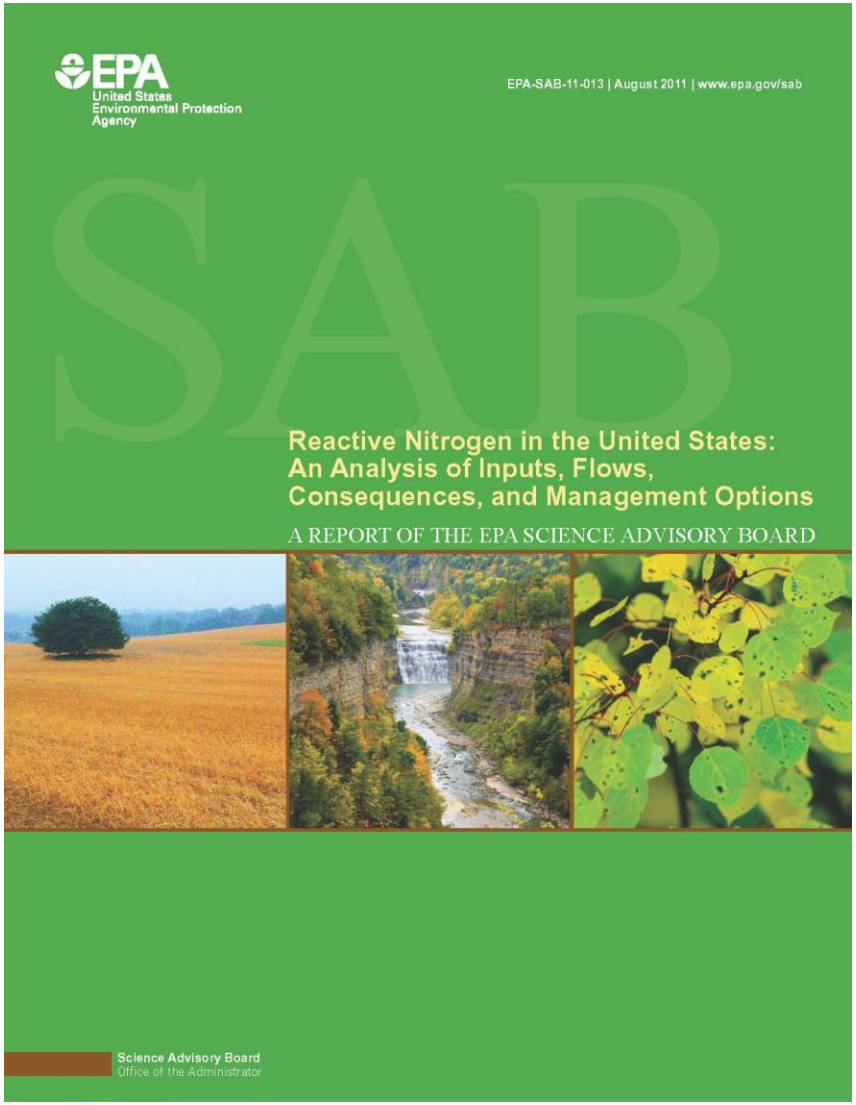
“By learning to draw fertilizer from a clear blue sky, chemists have fed the multitudes. They've also unleashed a fury as threatening as atomic energy.”-David E. and Marshall Jon Fisher, *The Nitrogen Bomb* (Discover Magazine, April 2001), http://discovermagazine.com/2001/apr/featbomb





Reactive Nitrogen in the United States

EPA Science Advisory Board (2011)

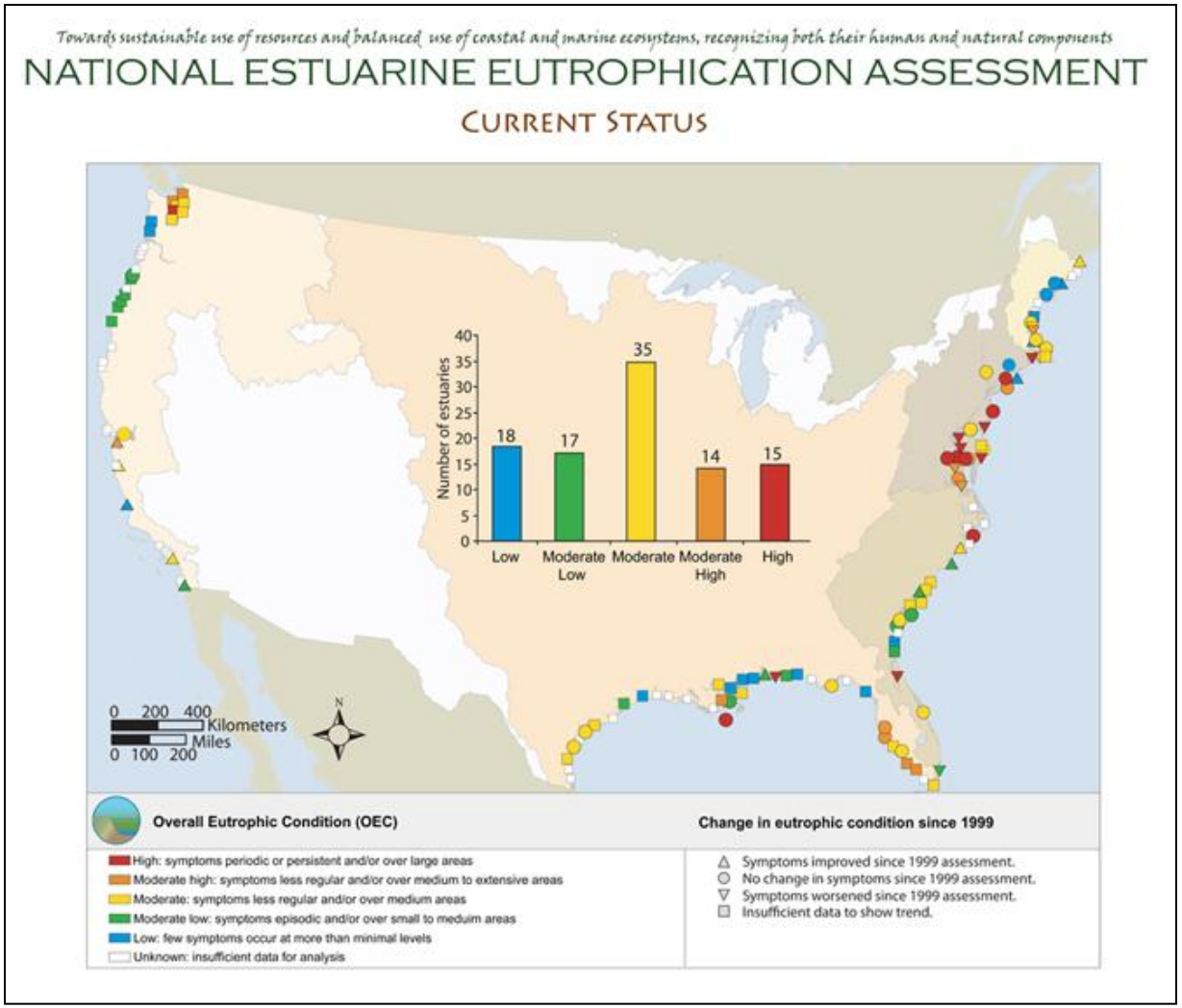


Clean Water Act Goals:
Biological and Chemical Integrity

I. Nutrient Pollution: Too Much of a Good Thing

- Excess nutrients (nutrient pollution) lead to:
  - Population Effects: Excess growth of algae (blooms)
  - Community Effects: Species composition shifts (dominant taxa)
  - Ecological Effects: Foodweb changes, Light limitation
  - Biogeochemical Effects: Excess organic carbon (eutrophication)
    - Dissolved oxygen deficits (hypoxia)
    - Toxin production
  - Human health effects
    - Excess nitrate in drinking water (blue baby syndrome)
    - Disinfection by-products in drinking water

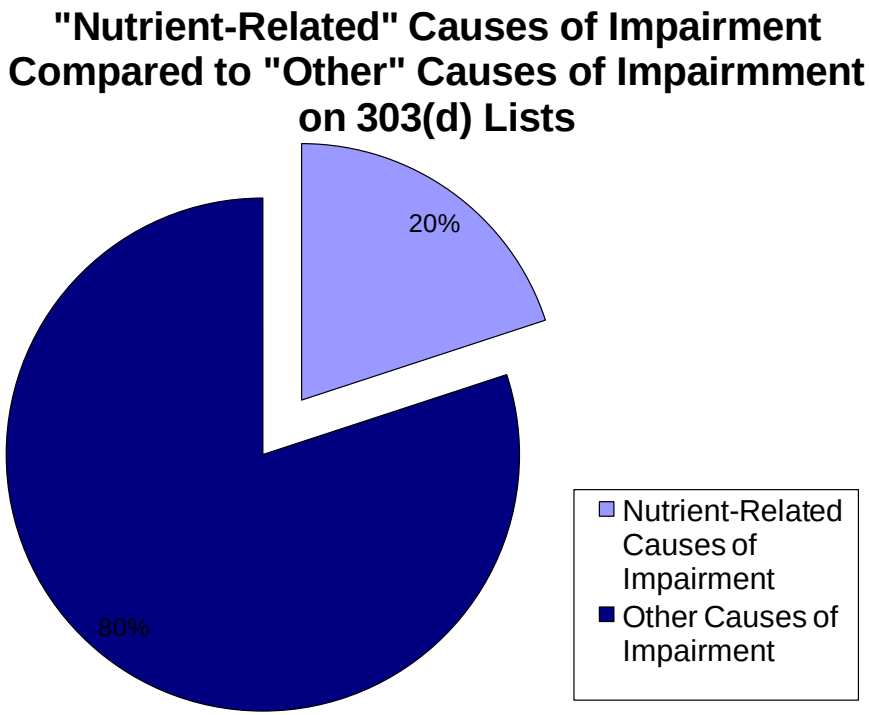
I. Nutrient Pollution: Ecosystem Changes

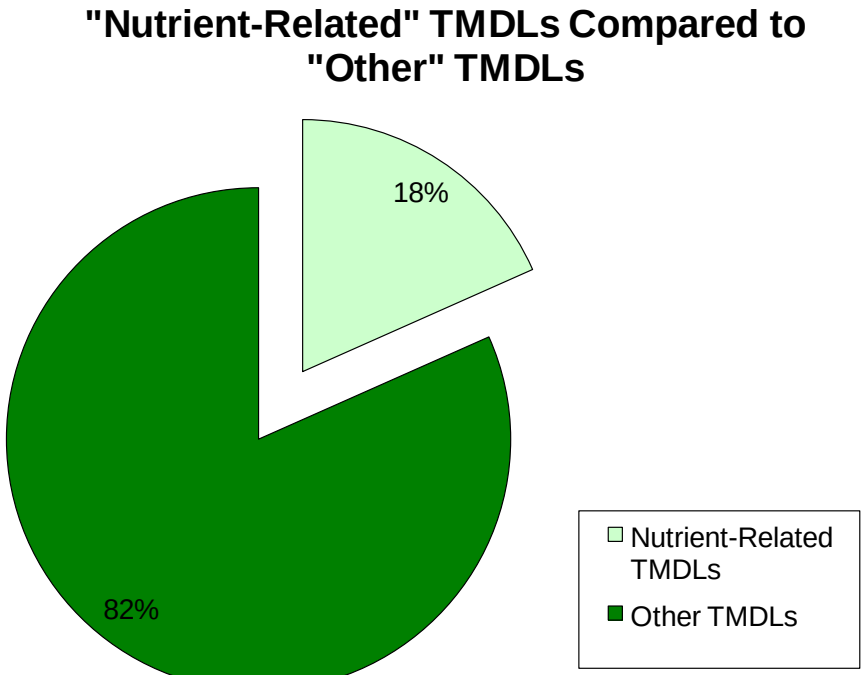


EPA Water Quality Standards Academy, December 13, 2011
http://www.epa.gov/waterscience/criteria/nutrient

Bricker et al., 2007 (NOAA)

National Nutrient-related listing and TMDL Results





- Of 75,677 impairments nationwide, 15,101 (20%) are “nutrient-related” (defined as ‘nutrients, organic enrichment/oxygen depletion, noxious plants, algal growth, and ammonia’).
- Of 40,698 TMDLs nationwide, 7,412 (18%) are “nutrient-related”

Based on the most recent 303(d) list data available in ATTAINS as of January 27, 2010 -- http://www.epa.gov/waters/tmdl/expert_query.html

Module Outline

I. Nutrient Pollution

II. Statutory and Regulatory Basis for Nutrient Criteria

III. EPA's National Nutrient Criteria Program

IV. Scientific Basis for Numeric Nutrient Criteria

V. Technical Approaches

VI. Current Events

Take Homes

1. What is the nutrient problem?
2. What is legal basis for nutrient criteria?
3. Why are numeric criteria for nutrients preferred?
4. What is the science behind why numeric nutrient criteria are important?
5. How are numeric nutrient criteria developed?
6. What are States and EPA currently doing?

II. Statutory and Regulatory Basis for Nutrient Criteria

Authority → *Clean Water Act*, *Code of Federal Regulations* (implement regulations), and *policies* that reflect the implementing regulations

- CWA 303(c)
  - WQS: protect public health, welfare, enhance water quality
- CWA 304(a)
  - Scientific information (guidance and recommendations)
- 40 CFR 131.11(a)
  - Criteria to protect designated uses
  - Contain parameters/constituents to protect designated uses
  - Based on a sound scientific rationale
  - Economics or attainability do not factor into the scientific rationale
- 40 CFR 131.10(b)
  - Take into account the attainment and maintenance of downstream WQS

Module Outline

I. Nutrient Pollution
II. Statutory and Regulatory Basis for Nutrient Criteria
III. EPA's National Nutrient Criteria Program
IV. Scientific Basis for Numeric Nutrient Criteria
V. Technical Approaches
VI. Current Events

Take Homes

1. What is the nutrient problem?
2. What is legal basis for nutrient criteria?
3. Why are numeric criteria for nutrients preferred?
4. What is the science behind why numeric nutrient criteria are important?
5. How are numeric nutrient criteria developed?
6. What are States and EPA currently doing?

III. EPA's National Nutrient Criteria Program

- 1998: National Nutrient Strategy (policy)
  - Created national nutrient and regional nutrient programs
  - Emphasized science and technical capacity in developing nutrient criteria
- 2000-2001, 2007, 2010: Technical Guidance Manuals (CWA 304(a))
  - Rivers/Streams, Lakes/Reservoirs, Estuaries, Wetlands, Stressor-Response guidance
- 2000-2001: Ecoregional Nutrient Criteria (CWA 304(a))
  - 14 ecoregions across the U.S.
  - TN, TP for Rivers/Streams, Lakes/Reservoirs
  - Reference approach, ambient WQ data

III. EPA's National Nutrient Criteria Program

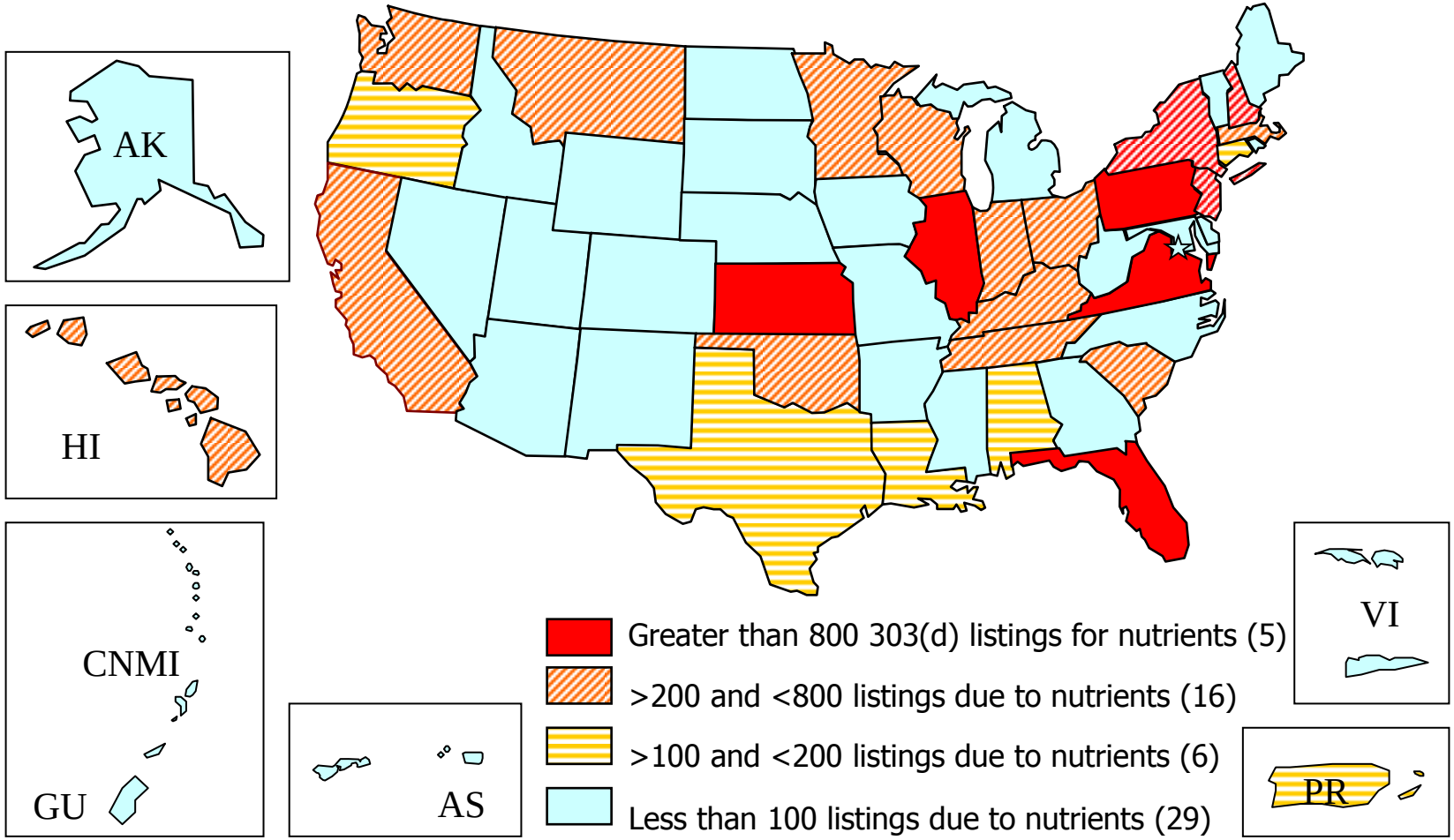
- 2004: EPA Office of Science and Technology (policy)
  - Defined EPA's expectations for numeric criteria
    - TN, TP, chl-a, clarity
  - Established "mutually-agreed upon plans" or roadmaps for State criteria development
- 2007: EPA Office of Water (policy)
  - Reiterated EPA's expectations for numeric criteria
  - Committed EPA to support State efforts
  - Advantages of numeric criteria (will come back to this)
- 2009: EPA Determination in Florida (CWA 303(c))
  - New or revised WQS for nutrients are *necessary*

III. EPA's National Nutrient Criteria Program

Advantages of numeric criteria (will come back to this)

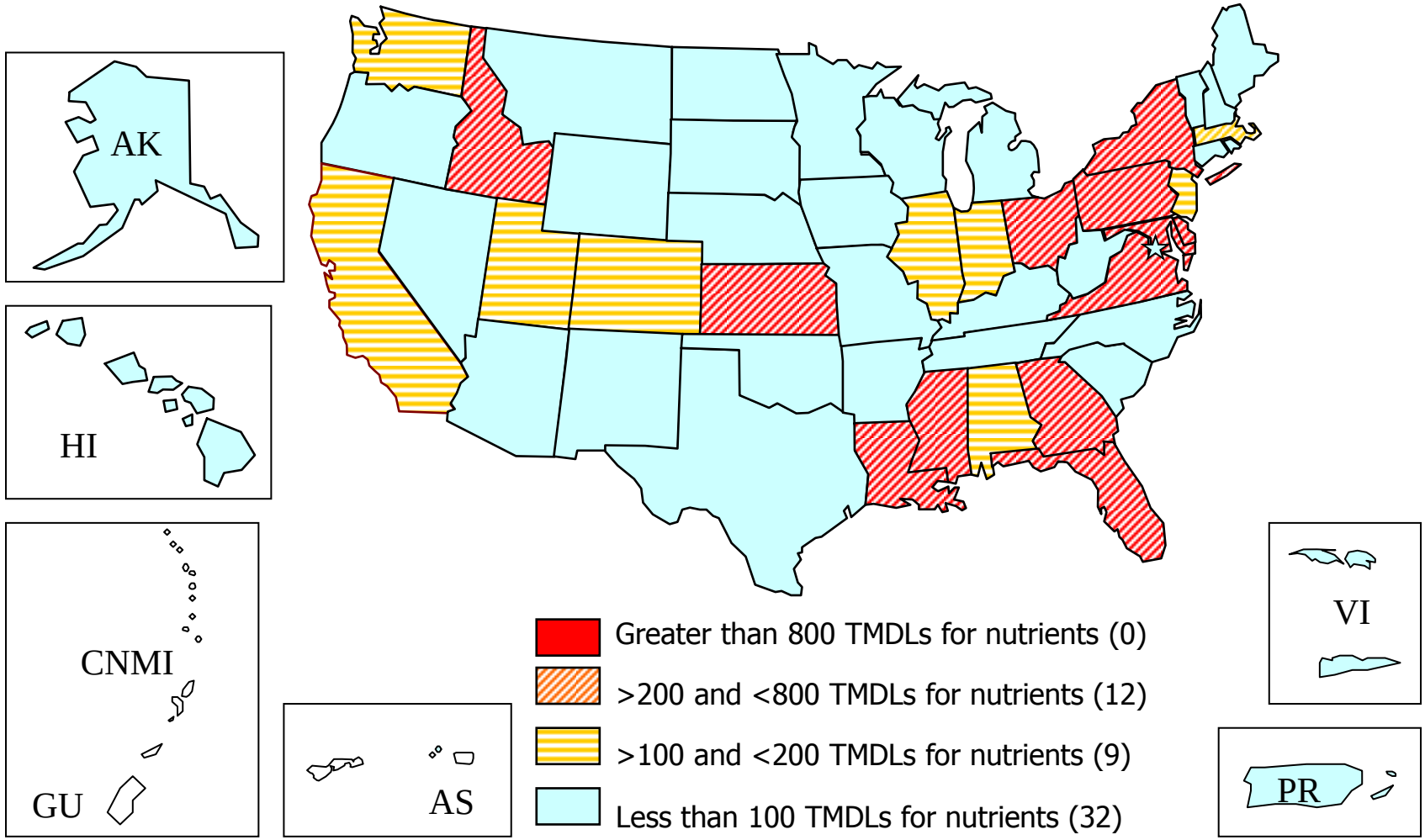
- Why are numeric nutrient criteria preferred?
  - Most State nutrient criteria are narratives
  - Example: *Nutrients shall not result in excess algal growth or other undesirable impacts (e.g., odor, scum).*
  - Narrative WQ criteria difficult to accurately implement for:
    - o *Monitoring, Assessment, and Listing (Impaired Waters List)*
    - o *Pollutant Limits (NPDES permits)*
    - o *Remediation (TMDL, nutrient budgets and allocations)*

States' 303(d) Listed Water Quality 'Nutrient-related' Impairments

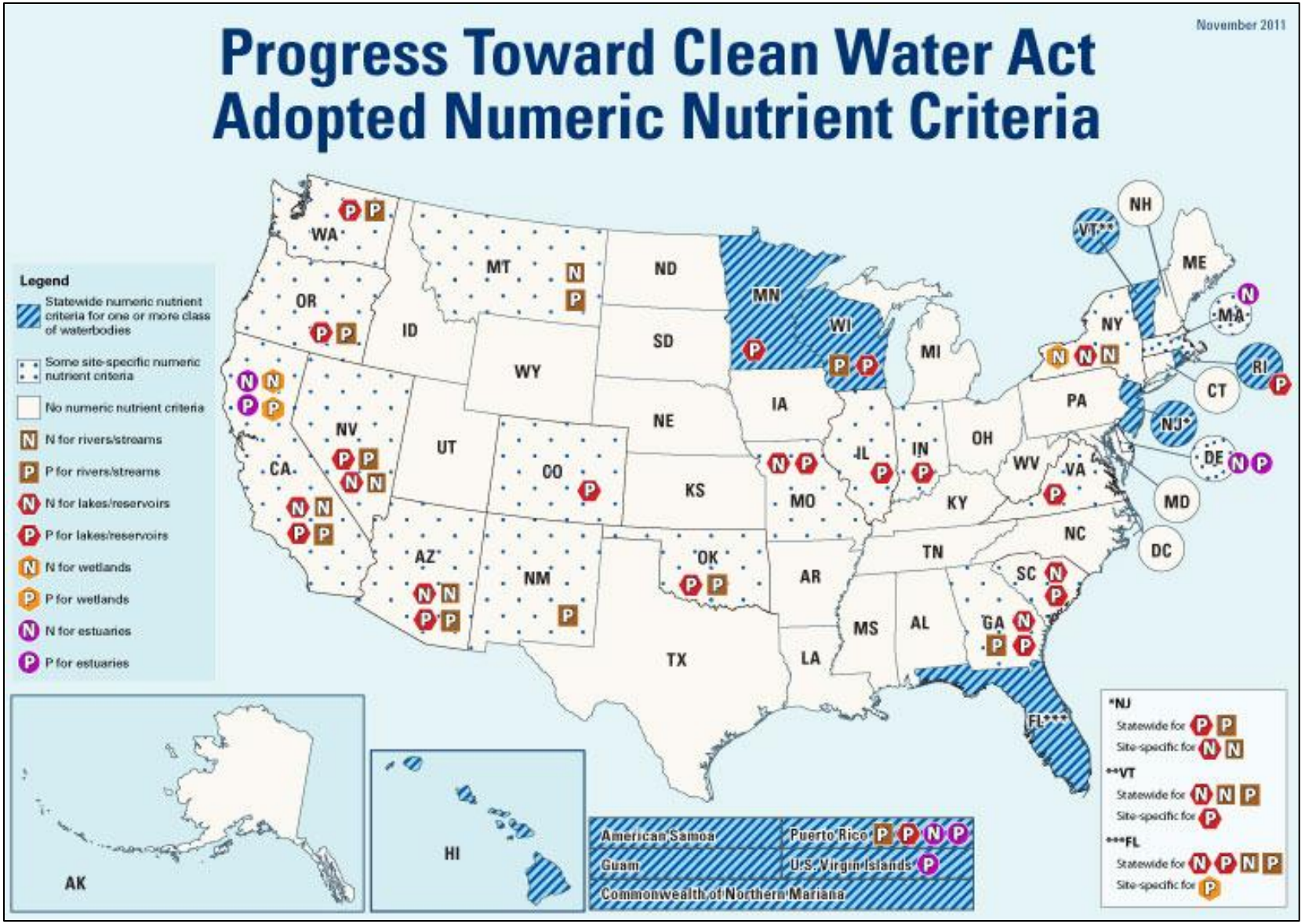


Based on information in Expert Query (ATTAINS) as of 10/23/2009. Of 75,675 impairments nationwide, 15,101 (20%) are due to nutrient-related defined as 'nutrients, organic enrichment/oxygen depletion, noxious plants, algal growth, and ammonia'. These data are based on the most recent 303(d) list data available in ATTAINS.

‘Nutrient-related’ TMDLs



Based on information in Expert Query (ATTAINS) as of 01/14/2010. 7,261 TMDLs were nutrient-related. Nutrient-related is defined as ‘nutrients, organic enrichment/oxygen depletion, noxious plants, algal growth, and ammonia’.



EPA Water Quality Standards Academy, December 13, 2011
http://www.epa.gov/waterscience/criteria/nutrient

Module Outline

I. Nutrient Pollution
II. Statutory and Regulatory Basis for Nutrient Criteria
III. EPA's National Nutrient Criteria Program
IV. Scientific Basis for Numeric Nutrient Criteria
V. Technical Approaches
VI. Current Events

Take Homes

1. What is the nutrient problem?
2. What is legal basis for nutrient criteria?
3. Why are numeric criteria for nutrients preferred?
4. What is the science behind why numeric nutrient criteria are important?
5. How are numeric nutrient criteria developed?
6. What are States and EPA currently doing?

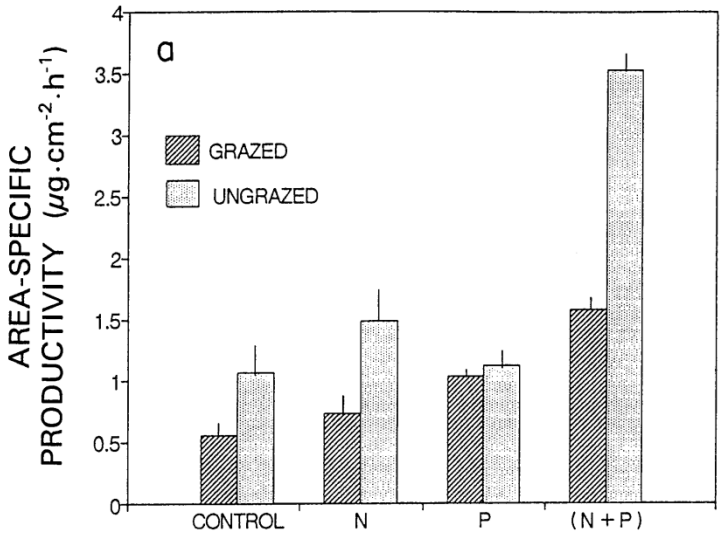
IV. Scientific Basis for Numeric Nutrient Criteria

- Importance of nitrogen and phosphorus
- Importance of chl-a and clarity
- Protecting downstream waters
- Ecological basis for independently applicable criteria

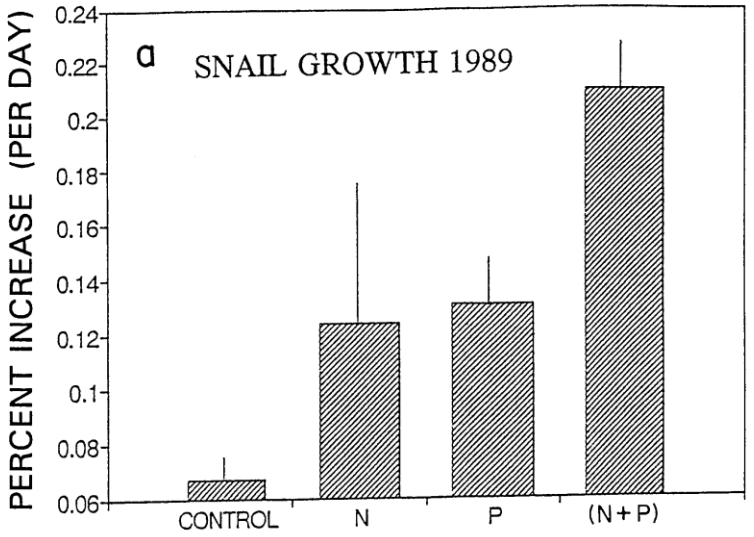
Without data, it's just an opinion.

IV. Scientific Basis: Importance of nitrogen and phosphorus

N and P stimulate Foodweb Productivity



Epiphytes



Snails

IV. Scientific Basis: Importance of nitrogen and phosphorus

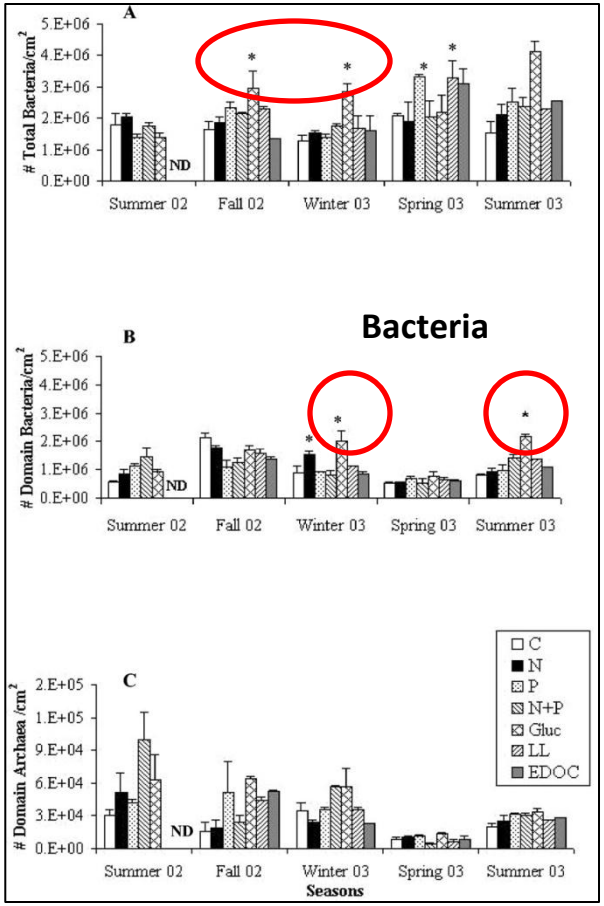
Excess N and P Causes Eutrophication

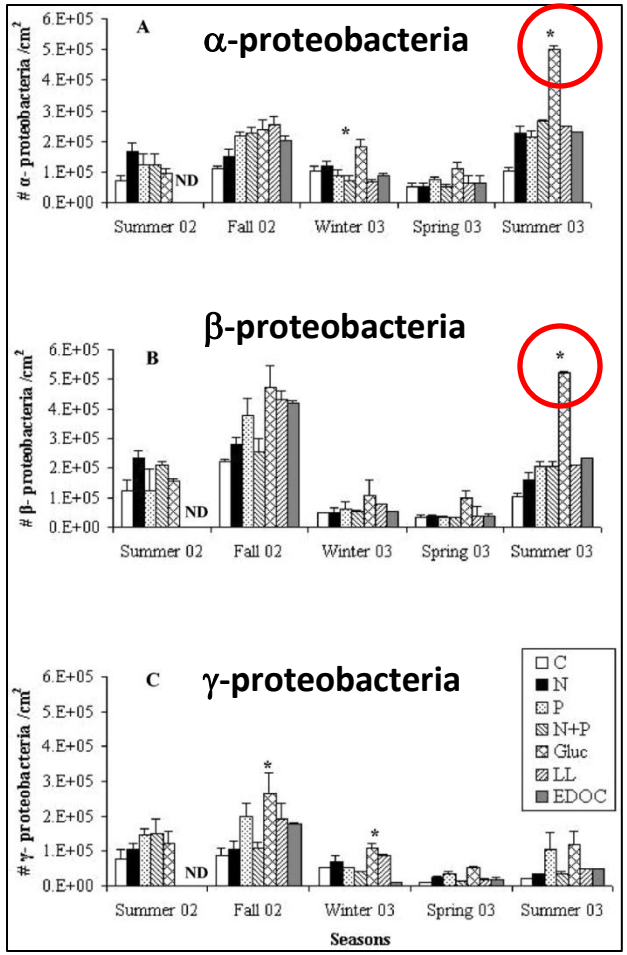
- Nixon, S. 1995. Coastal marine eutrophication: A definition, social causes, and future concerns. *Ophelia*.
- Smith et al. 1999. Eutrophication: Impacts of excess nutrient inputs on freshwater, marine, and terrestrial ecosystems. *Environmental Pollution*.
- National Research Council. 2000. Clean coastal waters: Understanding and reducing the effects of nutrient pollution.
- EPA Science Advisory Board 2007. Hypoxia in the northern Gulf of Mexico: Scientific assessment of causes and options for mitigation.

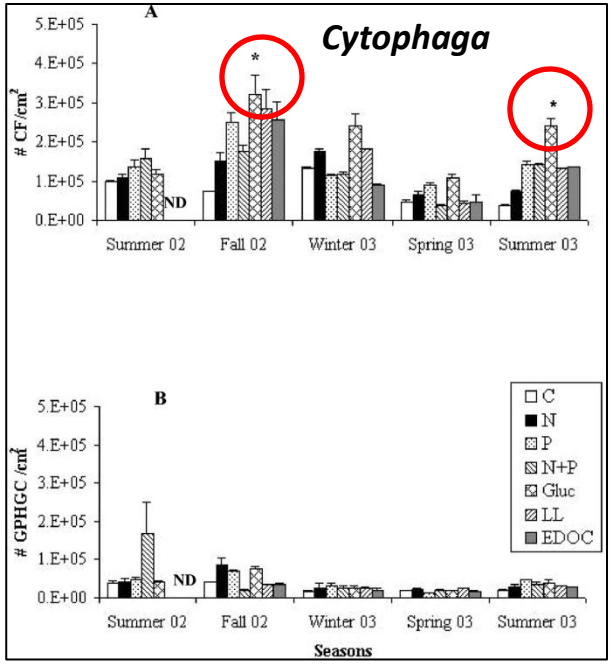
IV. Scientific Basis: Importance of nitrogen and phosphorus

Microbes* also respond to N and P

***The unseen majority who run the joint**







Olapade and Leff. 2005. **Seasonal Response of Stream Biofilm Communities to Dissolved Organic Matter and Nutrient Enrichments.** *App. Environ. Micro.*

EPA Water Quality Standards Academy, December 13, 2011
http://www.epa.gov/waterscience/criteria/nutrient

IV. Scientific Basis: Importance of nitrogen and phosphorus

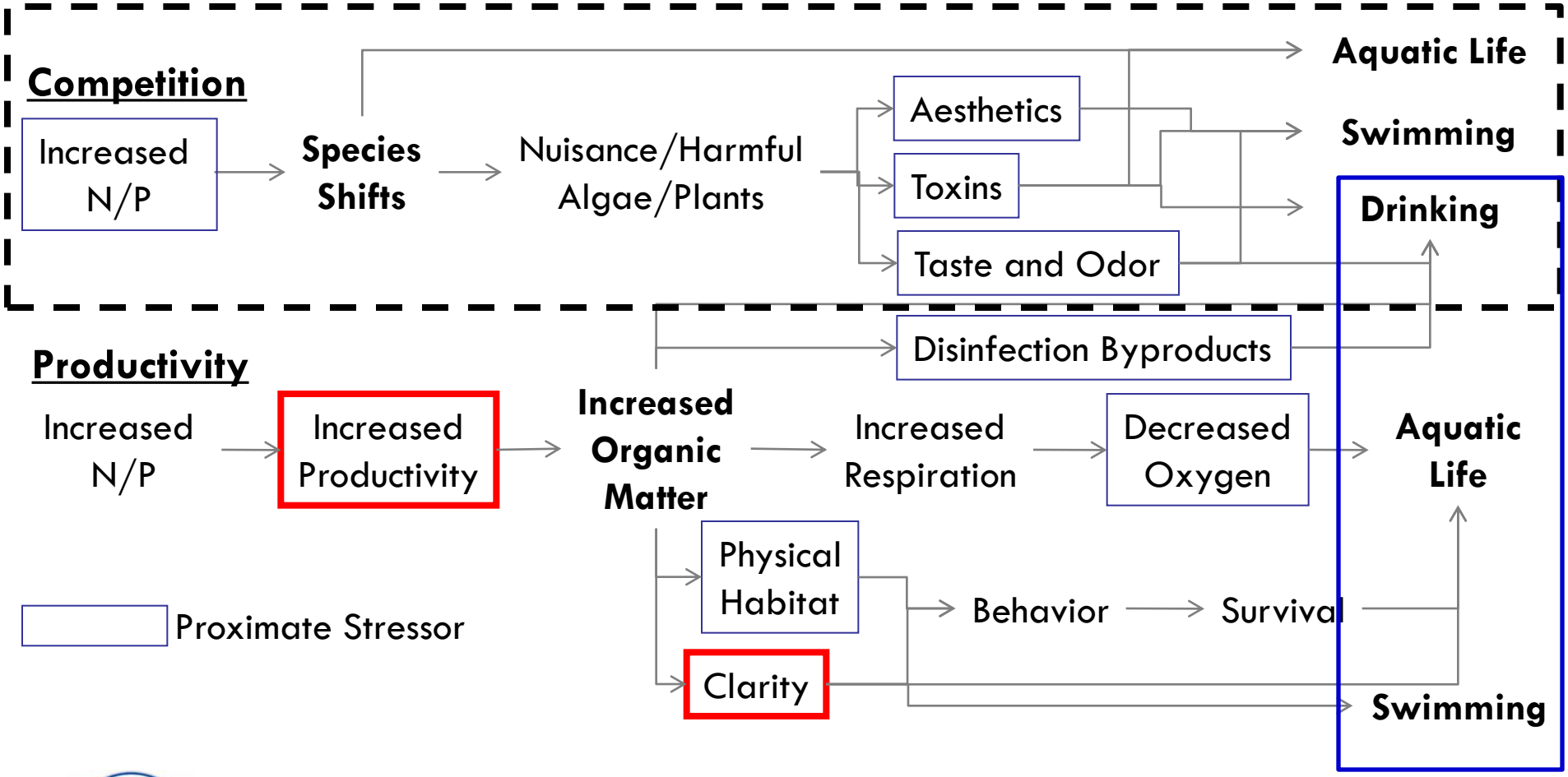
Control of one nutrient can lead to higher export downstream of the other nutrient

- Conley et al. 2009. Controlling eutrophication: nitrogen and phosphorus. *Science.*
- Paerl, H.W. 2009. Controlling eutrophication along the freshwater-marine continuum: dual nutrient (N and P) reductions are essential. *Estuaries and Coasts*.

IV. Scientific Basis: Importance of chl-a and clarity

- Nutrient concentrations = standing stocks measures
- Standing stocks = production - removal
- Nutrient concentrations = What's left over
- Nutrient concentrations may not tell the entire story in N or P-limited systems
- Chl-a and clarity are good indicators of nutrient enrichment in addition to N and P
  - Algal productivity is directly influenced by N and P
  - Algal biomass (chl-a) reflects productivity
  - Clarity is affected by algal biomass
- Chl-a and clarity affect designated uses in myriad ways

IV. Scientific Basis: Importance of chl-a and clarity

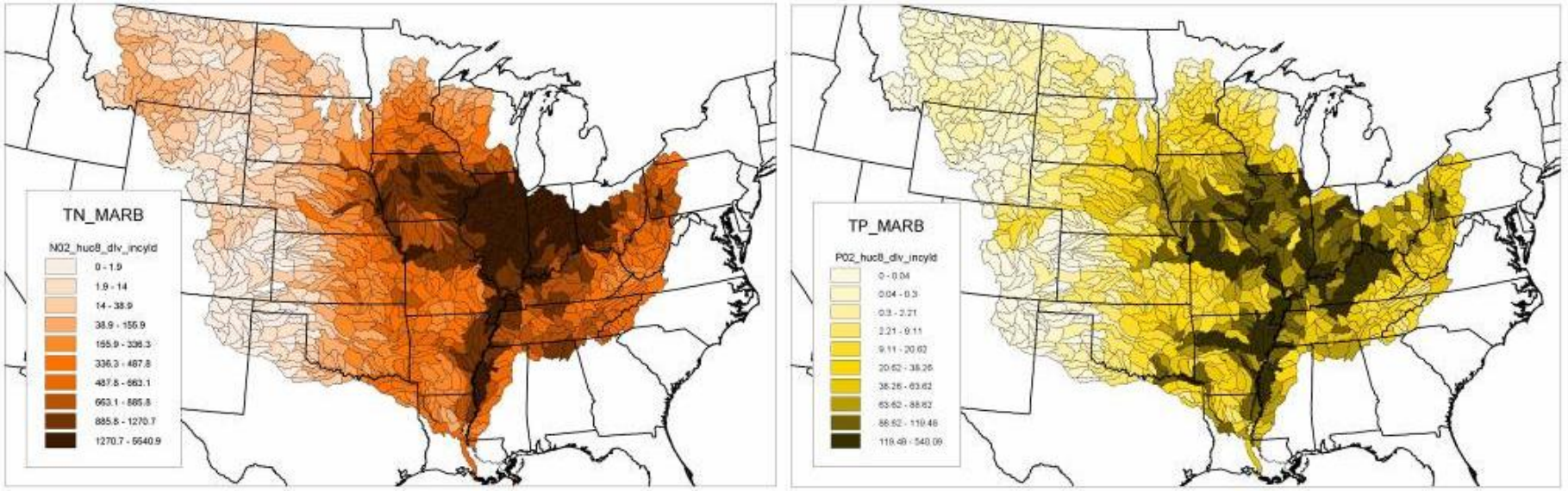


IV. Scientific Basis: Protecting downstream waters

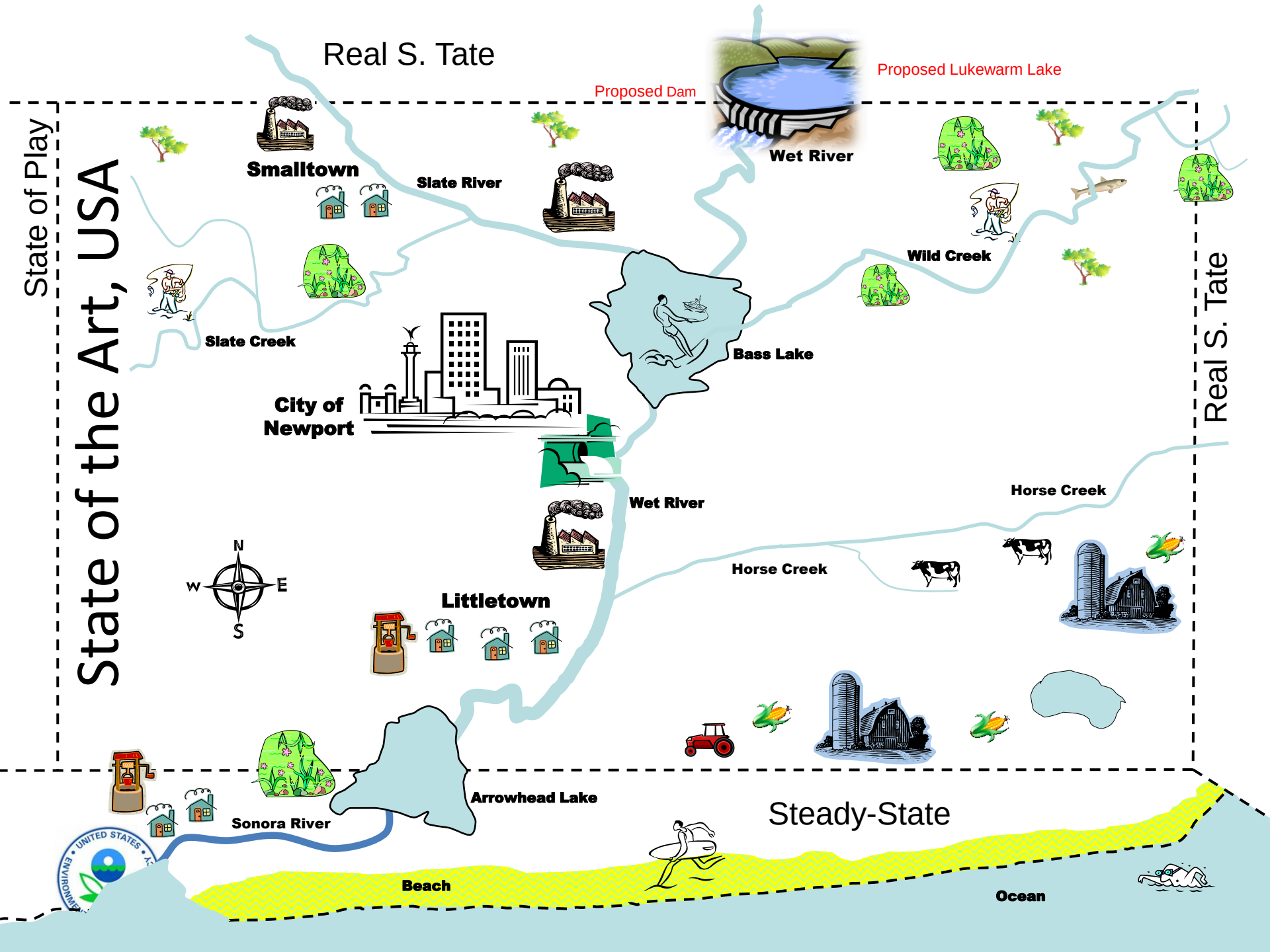
Downstream effects*: Temporal and spatial lags

***National Academy of Sciences, EPA SAB, Hypoxia Task Force, Gulf Alliance**

Delivered incremental yield of TN and TP to the northern Gulf of Mexico

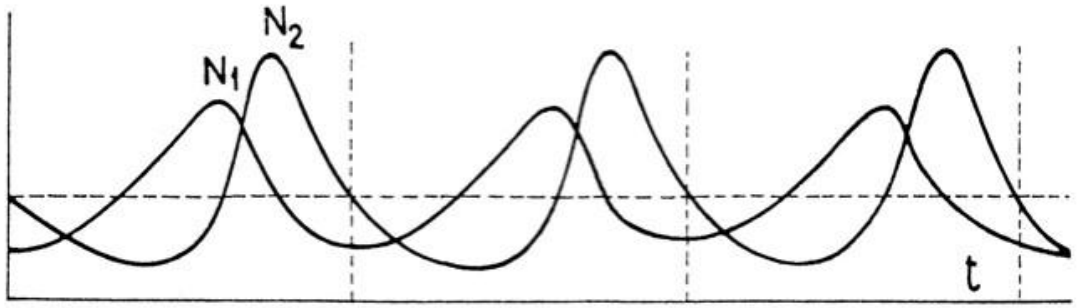


Dale Robertson, USGS SPARROW Model, *Statistical Methods for Ranking Watersheds in the Mississippi/Atchafalaya River Basin Using Results from the SPARROW Model*


Real S. Tate
Proposed Dam
Proposed Lukewarm Lake
Wet River
State of Play
State of the Art, USA
Smalltown
Slate River
Wild Creek
Slate Creek
Bass Lake
City of Newport
Real S. Tate
Wet River
Horse Creek
Horse Creek
N
W
E
S
Littletown
Arrowhead Lake
Sonora River
Steady-State
Beach
Ocean

IV. Scientific Basis: Ecological basis for independently applicable criteria

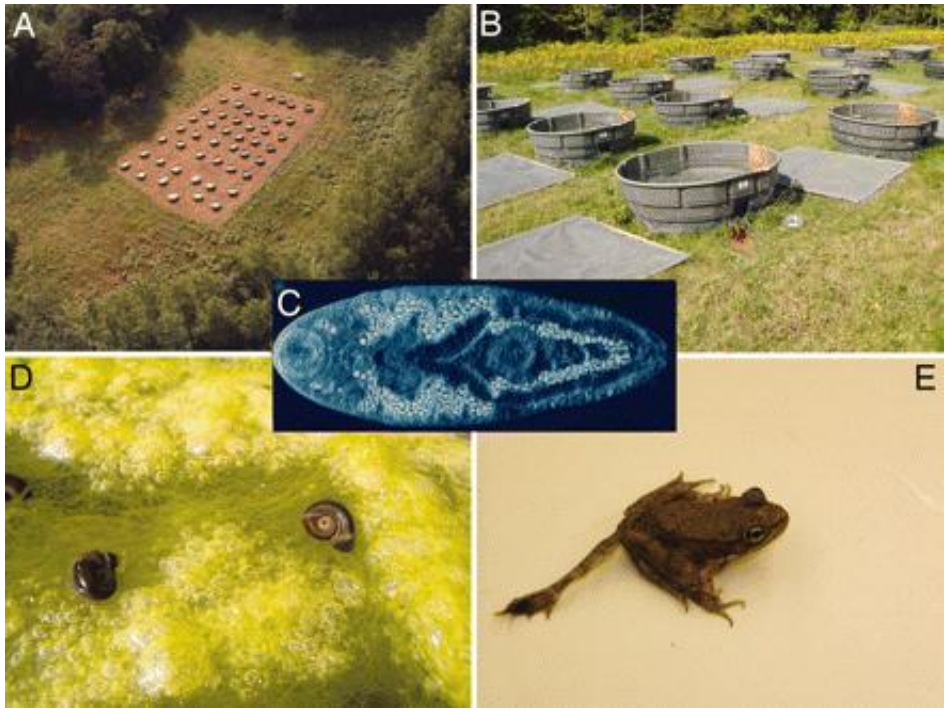
Foodweb dynamics can affect observation of response criteria and interpretation of actual nutrient effects



TIME and SPACE matter!

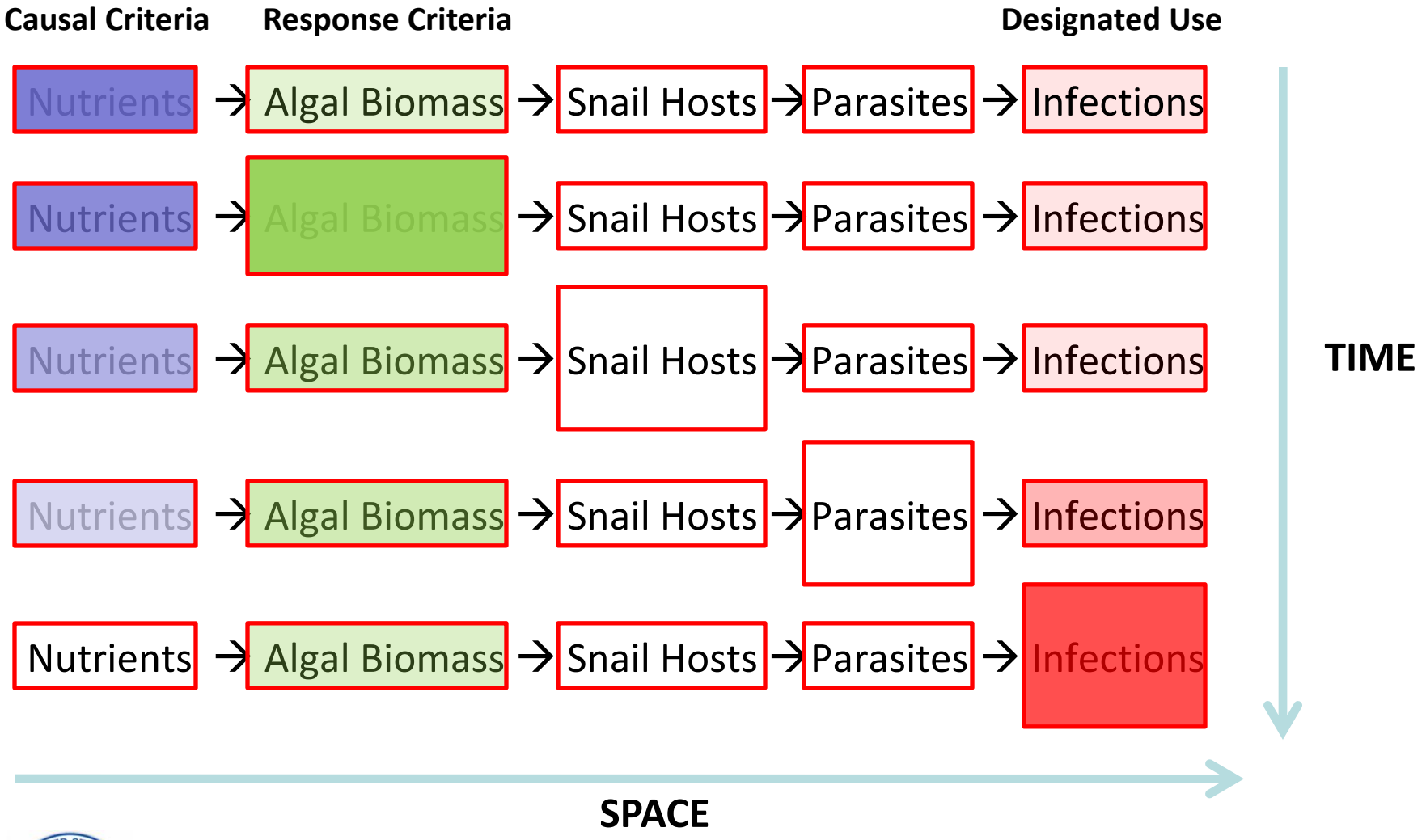
IV. Scientific Basis: Ecological basis for independently applicable criteria

Nutrients → Algal Biomass → Snail Hosts → Parasites → Infections → Deformities



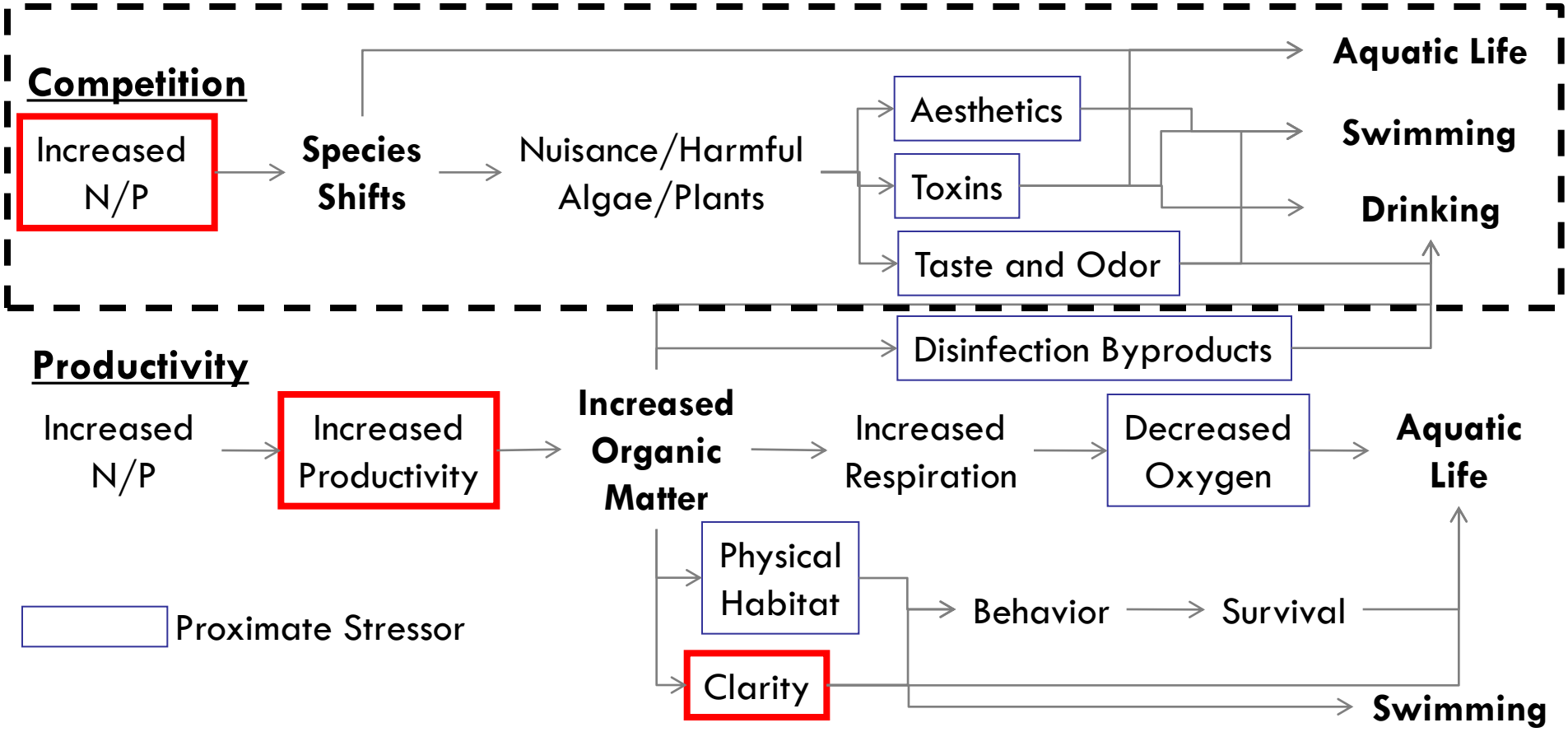
Johnson et al. 2007.
Aquatic eutrophication promotes pathogenic infection in amphibians.
Proc. Natl. Acad. Sci.

IV. Scientific Basis: Ecological basis for independently applicable criteria



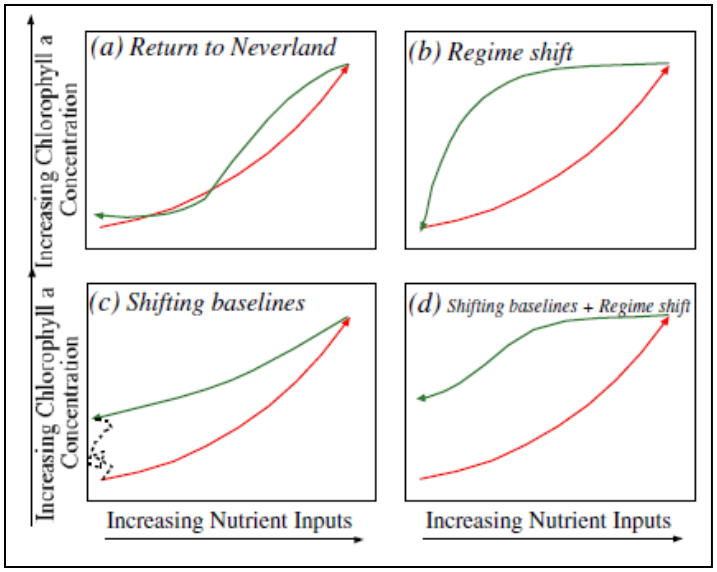
IV. Scientific Basis: Ecological basis for independently applicable criteria

EPA-recommended indicators of nutrient enrichment offer protection across variety of pathways for many different uses

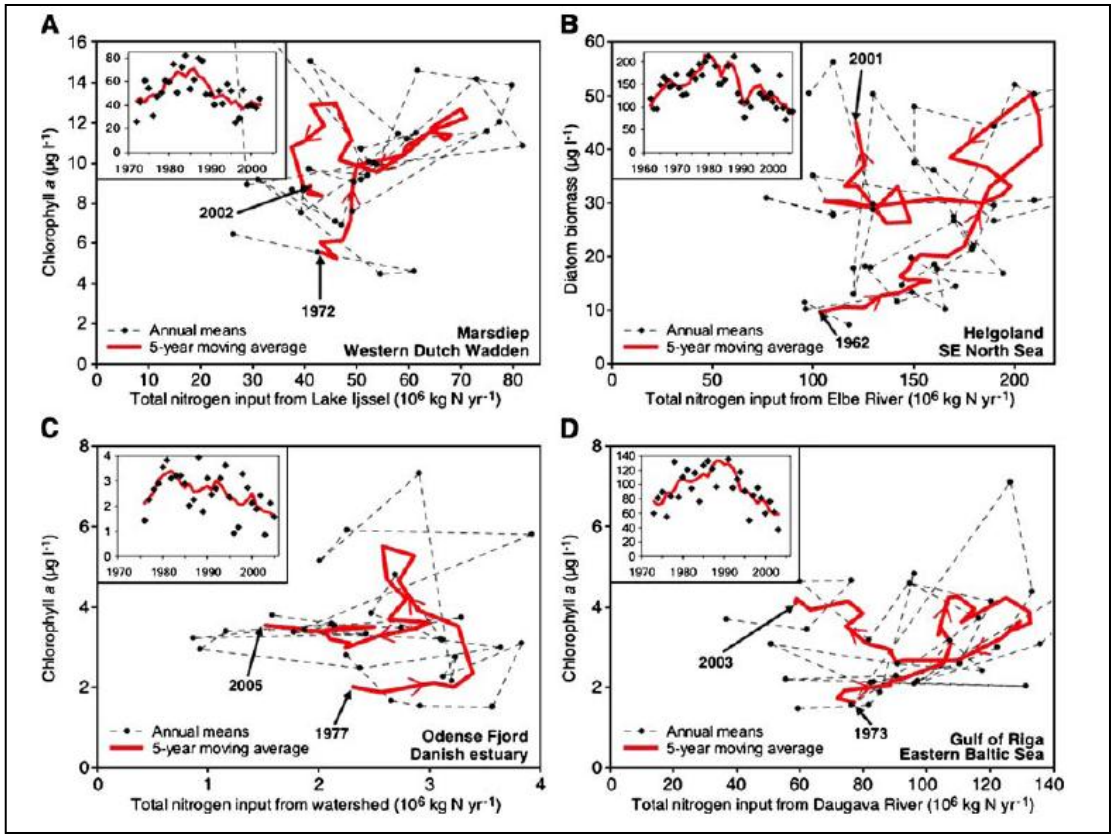


II. Science: Ecological basis for independently applicable criteria

Shifting baselines and hysteresis: Don't know what you've got 'til its gone



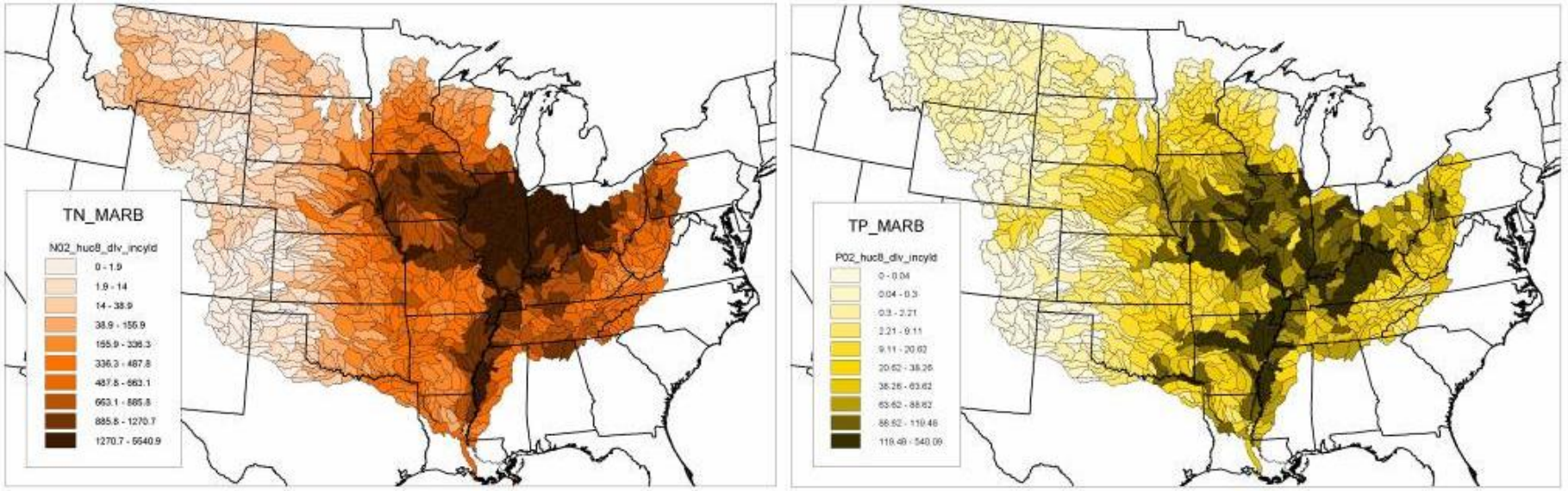
Duarte et al. 2008. **Return to *Neverland*: Shifting Baselines Affect Eutrophication Restoration Targets.** Estuaries and Coasts.



IV. Scientific Basis: Ecological basis for independently applicable criteria

Biological response only criteria risks downstream export of excess N and P

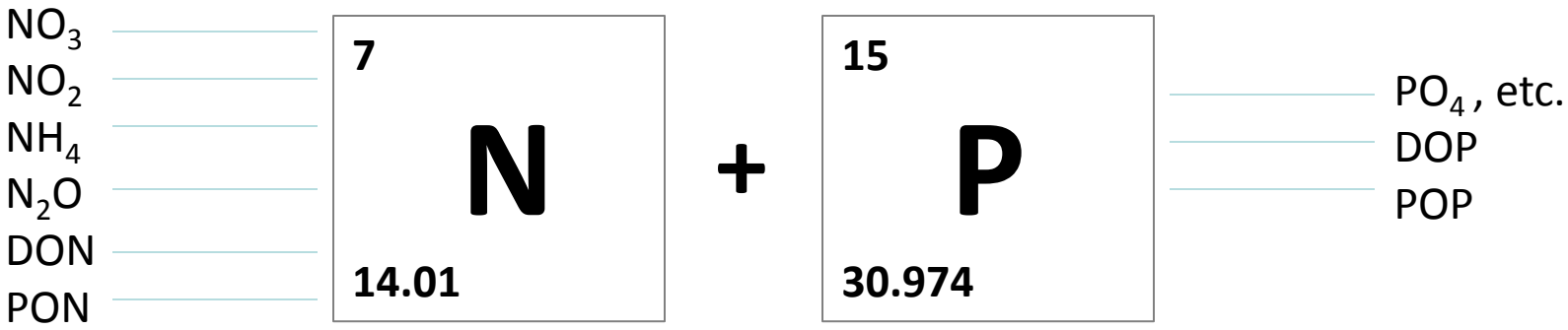
Delivered incremental yield of TN and TP to the northern Gulf of Mexico



Dale Robertson, USGS SPARROW Model, *Statistical Methods for Ranking Watersheds in the Mississippi/Atchafalaya River Basin Using Results from the SPARROW Model*

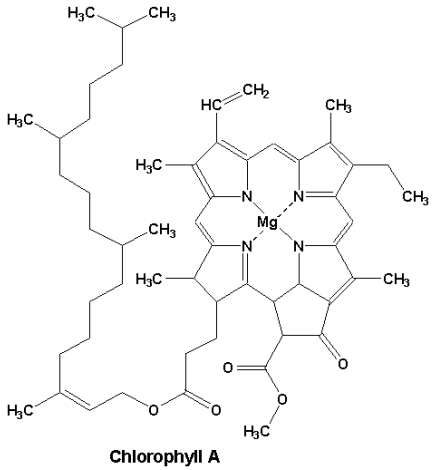
IV. Scientific Basis: Review

- Nitrogen **and** Phosphorus
  - N and P unequivocally drive eutrophication, which has adverse effects on designated uses
  - Dual control more effectively protects downstream waters
  - 131.11(a) – "…criteria must contain sufficient constituents…"

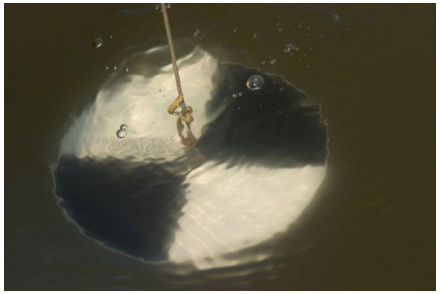


IV. Scientific Basis: Review

- Chl-a and clarity
  - Algal biomass and clarity unequivocally linked to N and P
  - Additional early indicators of nutrient enrichment
  - Strong empirical links to designated use protection
  - January 26, 2011, EPA Watershed Academy Webcast
    - "Nitrogen and Phosphorus Pollution and Harmful Algal Blooms in Lakes“ http://water.epa.gov/learn/training/wacademy/webcasts_index.cfm



Chlorophyll A

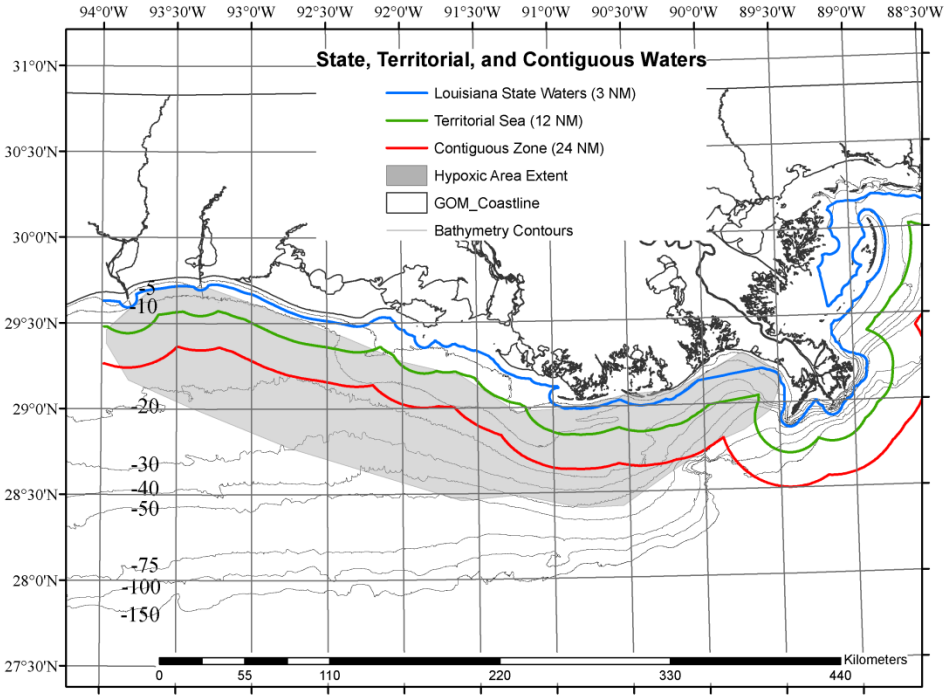


Russ Gibson, OH EPA
Watershed Academy Webcast, Jan. 26, 2011

EPA Water Quality Standards Academy, December 13, 2011
http://www.epa.gov/waterscience/criteria/nutrient

IV. Scientific Basis: Review

- Downstream protection
  - Nutrient source, transport, attenuation (or lack thereof), and adverse effects on designated uses have been widely observed
  - Numerous examples where tighter nutrient source control in upstream waters have led to remediation in downstream waters
  - 131.10(b) of the **WQS** regulations is a requirement



Courtesy, R. Greene , ORD, Gulf Ecology Division
(adapted from N. Rabalais, LUMCON)

IV. Scientific Basis: Review

- Independent applicability of criteria
  - Foodweb dynamics affect observation of biological responses; can lead to misinterpretations of biological response-only criteria (i.e., false negatives)
  - Potential for enhanced downstream export and impacts to downstream designated uses
  - Biological response criteria are functionally similar to narratives
    - Example: *Nutrients shall not result in excess algal growth or other undesirable impacts (e.g., odor, scum).*
    - Biological responses reflect effects and aren't necessarily preventative indicators of environmental harm – "late hits"
    - Are biological response criteria any better than narrative nutrient criteria for NPDES, assessment, and TMDL development?
  - CWA 303(d)(1)(A) – "Each State shall identify those waters for which effluent limitations…are not stringent enough to implement ***any water quality standard*** applicable to such waters." (emphasis added)

Module Outline

I. Nutrient Pollution
II. Statutory and Regulatory Basis for Nutrient Criteria
III. EPA's National Nutrient Criteria Program
IV. Scientific Basis for Numeric Nutrient Criteria
V. Technical Approaches
VI. Current Events

Take Homes

1. What is the nutrient problem?
2. What is legal basis for nutrient criteria?
3. Why are numeric criteria for nutrients preferred?
4. What is the science behind why numeric nutrient criteria are important?
5. How are numeric nutrient criteria developed?
6. What are States and EPA currently doing?

V. Technical Approaches

- 40 CFR 131.11(a)
  - Criteria to protect designated uses
  - Contain parameters/constituents to protect designated uses
  - Based on a sound scientific rationale

Numeric nutrient criteria development isn't rocket science. Its harder.

V. Technical Approaches

Where to Derive Numeric Nutrient Criteria?

- State by State, Waterbody by Waterbody
  - Interstate waters are a challenge
- Watershed Approach
  - Lakes + Lake watershed
  - Estuary + Estuary watershed

V. Technical Approaches

- Criteria = Magnitude + Duration + Frequency
- Combination provides protection of designated uses
  - Magnitude – Excursion level
    - Total Nitrogen not to exceed 0.65 mg/L
  - Duration – Averaging period
    - Annual, monthly, seasonal
  - Frequency – Rate of excursions of the magnitude + duration
    - More than 50% of the time (over 4 years)

V. Technical Approaches

How to Derive Numeric Nutrient Criteria?

- Approaches
  - Classification
  - Scientific literature and expert judgment
  - Mechanistic models
  - Reference condition
    - Statistical distribution
  - Empirical stressor-response (effects-based)
  - Multiple lines of evidence

V. Technical Approaches

Classification: Organizing waters to reduce variability

- Lakes
  - Designated use: fishing, drinking water
  - Residence time: long, short
  - Geochemical factors: color, alkalinity
- Streams
  - Designated use: warm, cold water fishery
  - Stream order: wadeable, non-wadeable
  - Geochemical factors: color, phosphorus geology

V. Technical Approaches

Empirical Models

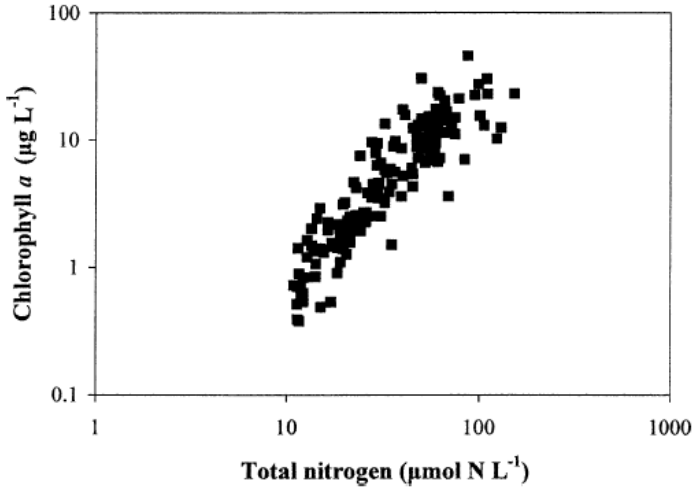
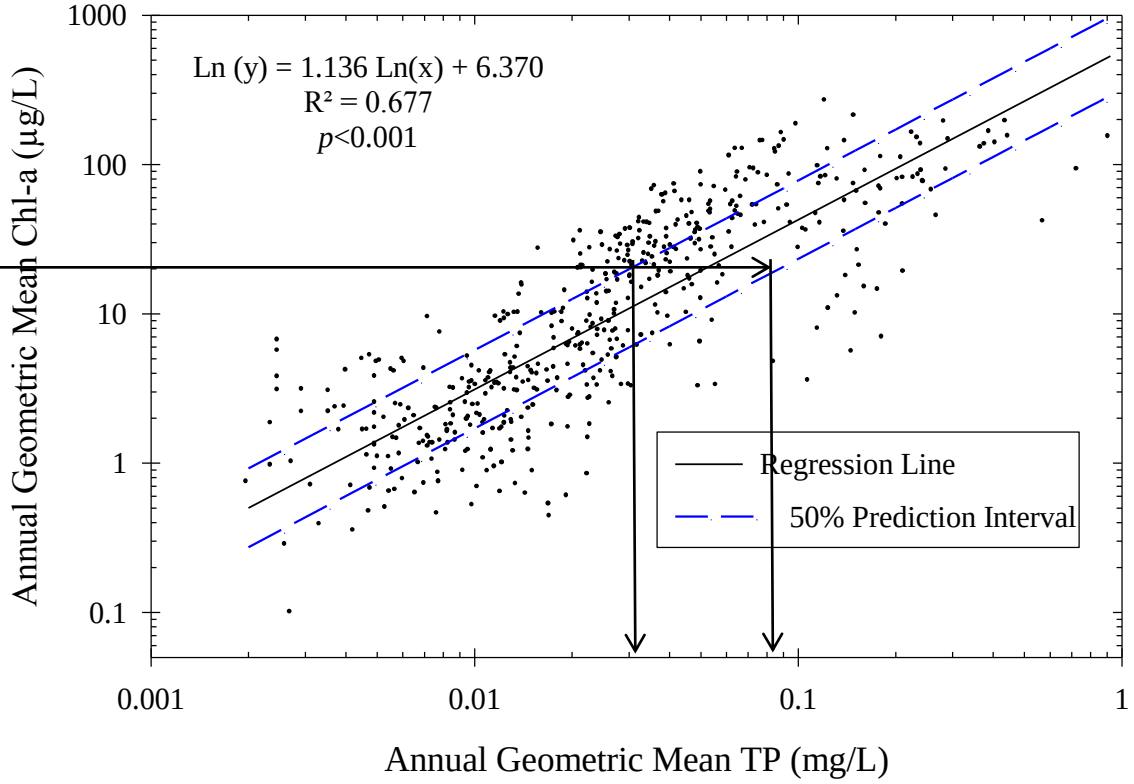


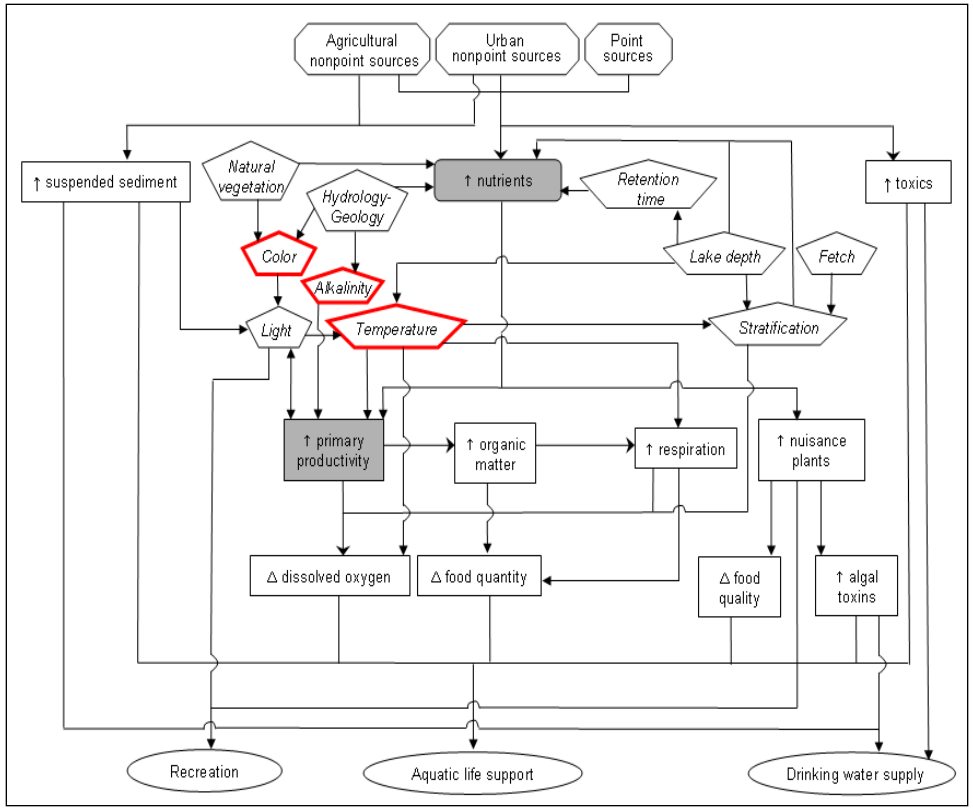
Fig. 1. Relationship between annual mean Chl *a* and annual mean TN concentrations in estuarine and coastal marine ecosystems.

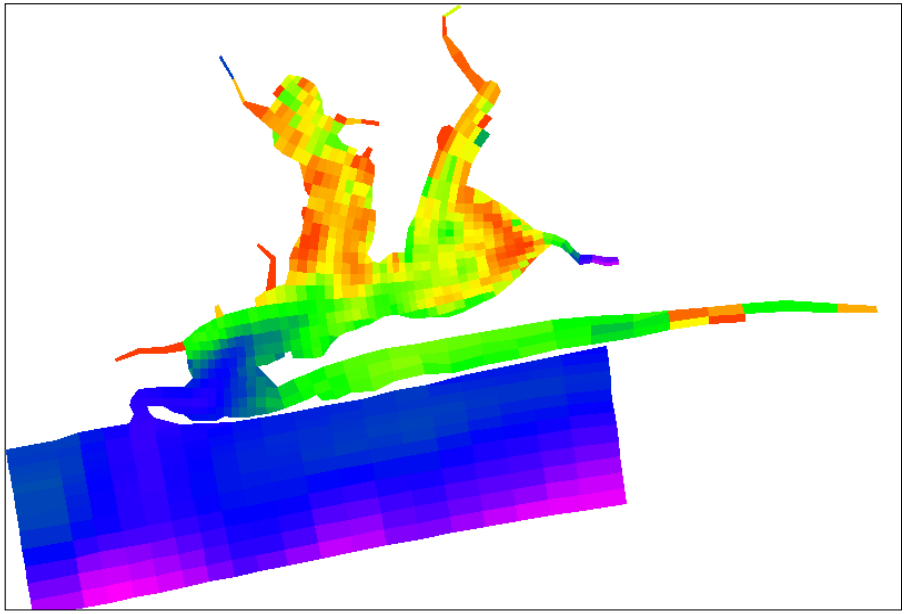
Smith, 2006 (L&O)



V. Technical Approaches

Mechanistic modeling





Numerical simulation models

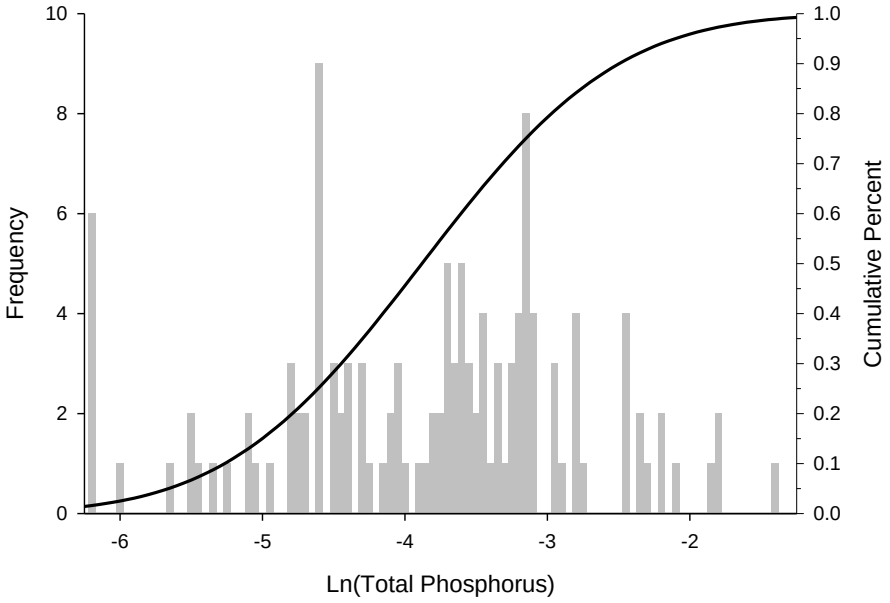
V. Technical Approaches

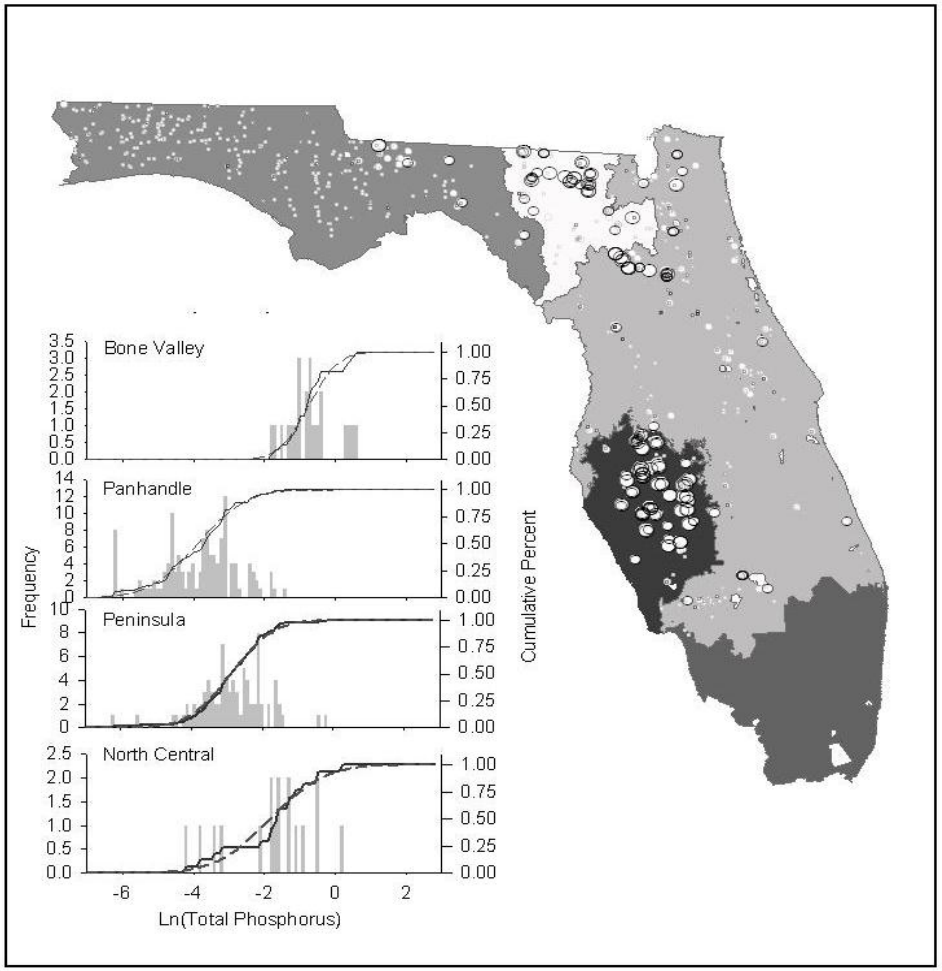
Reference Condition

- Reference waters – similar waterbody, historical condition of current waterbody
- Paleo proxies (sediment cores indicators)
- Historical data
- Surrounding land use (minimize human disturbance)
- Modeled reference conditions

V. Technical Approaches

Reference Condition





Module Outline

I. Nutrient Pollution
II. Statutory and Regulatory Basis for Nutrient Criteria
III. EPA's National Nutrient Criteria Program
IV. Scientific Basis for Numeric Nutrient Criteria
V. Technical Approaches
VI. Current Events

Take Homes

1. What is the nutrient problem?
2. What is legal basis for nutrient criteria?
3. Why are numeric criteria for nutrients preferred?
4. What is the science behind why numeric nutrient criteria are important?
5. How are numeric nutrient criteria developed?
6. What are States and EPA currently doing?

VI. Current Events – Florida Rulemaking

EPA's Rulemaking in Florida – 303(c)(4)(B) Determination, January 2009

- Inland Freshwaters
  - Proposed Rule – January 2010
  - Supplemental Notice – August 2010
  - Final Rule promulgating numeric criteria – November 2010
- Estuaries and Coastal Waters
  - EPA Science Advisory Board – May 2011
  - Proposed Rule – March 2012
  - Final Rule – November 2012
- 12 lawsuits (State, counties, municipal, industrial, agricultural, environmental advocates)
- State of FL petition to rescind 2009 Determination – April 2011
  - Repeal November 2010 final rule promulgating numeric criteria
  - Stop current rulemaking for estuaries and coastal waters

VI. Current Events – Around the Country

- EPA partial disapproval of Louisiana's 303(d) list
  - Addition of three coastal segments for dissolved oxygen impairment
- EPA memo to States – Framework for nutrient reductions (Stoner memo)
  - Eight recommendations, including developing plans for adopting numeric nutrient criteria
- State numeric nutrient criteria development efforts
  - Maine
  - New Hampshire
  - Ohio
  - Pennsylvania
  - Louisiana
  - Mississippi
  - California

VI. Current Events – National Program Activities

- Building technical capacity for criteria development
  - N-STEPS (Nutrient Scientific Technical Exchange Partnership and Support)
    - http://n-steps.tetratech-ffx.com/
  - Data analysis
  - Scientific and expert review of State draft criteria
  - Webcasts on technical approaches
  - Online bibliography of scientific journal articles

Water Home
Drinking Water
Education & Training
Grants & Funding
Laws & Regulations
Our Waters
Pollution Prevention & Control
Resources & Performance
Science & Technology
Analytical Methods & Laboratories
Applications & Databases
Climate Change
Contaminants of Emerging Concern
Drinking Water
Monitoring & Assessment
Research & Risk Assessment
Surface Water Standards & Guidance
Wastewater Technology
Water Infrastructure
What You Can Do

You are here: Water » Science & Technology » Surface Water Standards & Guidance » Water Quality Standards » Water Quality Criteria » Water Quality Criteria for Nitrogen and Phosphorus Pollution

Water Quality Criteria for Nitrogen and Phosphorus Pollution

Quick Finder

About N and P Pollution
Current Efforts
Developing State Criteria
Effects of N and P Pollution
Glossary
Hypoxia, Anoxia, and HABs
N and P Pollution Data Access Tool
Related Links
State Progress
Take Action
The Problem
What EPA and the States are Doing
Where N and P Pollution Occurs
Where You Live
Why This Is Happening

About Nitrogen and Phosphorus Pollution

Nitrogen and phosphorus (also referred as nutrients) are natural elements in the environment that are essential for plant and animal growth, maintenance and reproduction. However, the contamination of water by too much nitrogen and phosphorus is a growing concern in the United States. The site is designed to provide basic information about nitrogen and phosphorus pollution, sources, and how people can take action to reduce the amount of nitrogen and phosphorus pollution that they generate. If you want to learn more, visit the links to general and region-specific waterbody and nitrogen and phosphorus pollution information.

Learn More

- The Problem
- Why This is Happening
- Take Action

Developing Numeric Nutrient Criteria

This section is targeted to states. EPA encourages states to develop and adopt numeric criteria to address nitrogen and phosphorus pollution. Find the resources EPA has made available to facilitate this process.

Status of State Criteria Development

Which states have developed numeric nutrient criteria? Which states have not? Learn more about the progress of state criteria development.

Questions?